First Report of the Yale-Bombay Natural History Society studies of Wild Ungulates at the Gir Forest, Gujarat, India

BY

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(With a plate)

INTRODUCTION

This report covers the first four months, March-June, 1970 of field work in the collaborative research project, "Habitat Relationships, Numbers, and Distribution of Wild Ungulates in the Gir Forest, India", Smithsonian Institution Grant No. SFG-0-1894 funded under the Public Law 480 foreign currency surplus programme.

The Gir Forest in Gujarat State, India, has long attracted the attention of conservationists in India and elsewhere because it holds the last remnant population of the Asiatic Lion, *Panthera leo persica*. The Gir is further valued by ecologists for having the largest and virtually only representation of the original flora and fauna once widespread through semi-arid northwestern India. During a survey of the threatened fauna of southeastern Asia, Talbot (1960) concluded that the Gir lion was in serious jeopardy both from direct killing and from deterioration of the Gir Forest by excessive livestock pressure.

Considering the great difficulty of preserving a natural community of over 400 square miles where exploding population and under-nutrition create a great demand for agricultural development, the Gujarat forest department has done well in holding the Gir as a wildlife sanctuary. It is further encouraging to note that a totally protected 75 square mile national park is being planned within the Sanctuary. The State has received encouragement in these efforts from the Government of India and from conservation groups the world over. Authorities also realise that if large-scale tourism is to be developed, fauna and flora must be preserved. Nevertheless, the continued presence of tens of thousands of livestock depleting vegetation and soils of the Gir plus slow but steady incursions of cultivation around the edges, forces the question of how long can the Gir support the lion and other large wildlife? There are of course both political and ecological questions, all of which must soon be answered if this valuable natural community is to be preserved. The present study addresses a key ecological aspect: what are the requirements and

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current status of the ungulate species of the Gir—that set of animals which comprise the natural or wild food of the lion.

In October 1968, Jordan submitted for the School of Forestry, Yale University, a proposal to the Smithsonian Institution to study the wild ungulates of the Gir. Simultaneously, Mr. Futehally submitted for the Bombay Natural History Society a parallel proposal to the Indian Screening Committee, in accordance with procedures for involvement of P.L. 480 funds for ecological investigations. In March, 1969, Jordan, accompanied by Dean Francois Mergen and Professor W. R. Burch of the Yale School of Forestry, visited India to meet collaborators and evaluate research opportunities. Both of the above proposals, after some delay and revision, were approved during 1969. Yale's participation involves mainly the full-time field work of Mr. S. H. Berwick, a doctoral candidate doing this research for his dissertation. In addition to collaborating with various Indian scientists, Mr. Berwick will assist several Indian student fellows in independent study related to the overall objectives of the Yale-BNHS programme.

The studies outlined in the proposal and slightly amended in a subsequent document by Berwick, involve censusing and comparing niche relationships among six species of ungulates now extant and one recently extinct within the Gir. These are the wild boar (*Sus scrofa*), chinkara or Indian gazelle (*Gazella gazella bennetti*), four-horned antelope (*Tetracerus quadricornis*), nilgai or blue bull (*Boselephas tragocamelus*), chital or spotted deer (*Axis axis*), and the sambar (*Cervus unicolor*); the locally extinct species is the blackbuck or Indian antelope (*Antilope cervicapra*).

Ungulate populations at the Gir now are apparently far below levels assumed normal for this region were habitat not disturbed. Restoration of ungulate numbers is critical not only to maintaining the original natural community but also to providing enough wild prey for the lions as well as for the other large carnivores here—leopards, wolves, and hyenas. Lions, according to Joslin's studies (1969), now subsist largely on domestic animals, a situation which is neither good for the lions (biologically or politically) nor for the local economy.

The Yale-BNHS research in designed to provide heretofore little known information on the comparative ecology of these large herbivores as they coexist in this part of the world. By field observation and experiments with penned, semi-tame specimens, feeding niches and climatic tolerances are being compared. Numbers, population dynamics, and habitat affinities are being measured and compared. The combined results

should reveal the causes of current underpopulation and hence, suggest management strategies for restoring these species to normal levels.

Numbers, Distribution and Composition of Ungulates

A first priority at the Gir was estimation of numbers and distribution of each species of ungulate. A survey for this purpose had been made by Joslin the previous year.

(*a*) *Techniques*

To properly sample a large area such as the 450 square mile Gir, one must use a wide ranging, uniform technique. Fortunately the Gir is covered by a network of roads being rather evenly spaced and traversing all habitats except steep hills. Furthermore, density of vegetation during the dry season, i.e. after the many deciduous trees and shrubs have shed their leaves, affords consistent visibility of animals back 20-200 metres from the road. Thus it was possible to use a strip-count sampling similar to that described by Hirst (1969). From west to east along a gradient of diminishing moisture, the density of vegetation diminishes. The Gir was divided into three regions each characteristically different in dominant vegetation—west, middle, and east. Census sampling was then stratified according to this division.

Extrapolating density from strip counts requires that strip-width be estimated as accurately as the number of animals within the strip. To estimate average maximum distance at which the average sized ungulate is visible, tests were made with cardboard models the size and colour of chitals, the median-sized species and also the most abundant one. For night spot lighting, a model with eye-like reflectors was substituted. From randomly chosen points along the road, one man moved the model away while another, watching from a jeep, indicated when the model could no longer be seen. The disappearance distance was then measured by tape. For both night and daylight visibility, 70 tests each were made to obtain a mean distance. Hirst (1969) compared stationary-observer results with the spotting of randomly placed models from a moving vehicle and found no significant difference between the two methods. Strip-width equals two times disappearance distance since counts are made from both sides of the vehicle. Strip-widths in 1970 were determined only for the mixed teak forest typical of the middle region: there was inadequate time for testing elsewhere. Widths were 128 and 100 metres for daylight and night respectively. It will be possible to test in several other types next spring. If widths are found to be different elsewhere, this year's figures can be subsequently recalculated, since all records are kept by map location.

Above: Acacia Forest, Eastern Gir.
Below: Measuring 'disappearance distance'.
(*Photos: Author*)

Counts were made between 23 March and 11 May. Daylight runs were confined to the cool, early hours of 6-9 a.m. while the 2-4 hours of night counting started ½ hour after darkness (about 7.45 p.m.). When, for a given area, both day and night counts were made, the same road was run for both counts on the same day. Otherwise there was no repetition of road coverage. For each species in each region, density estimates based on daylight *vs.* darkness counts were compared, and the higher figure was selected for subsequent calculations. It is reasoned that highest counts will result when feeding activity in the species is greatest, i.e. when most animals are on their feed. Since strip-width estimates are based on visibility of standing animals, consistency dictates that counts be made whenever the greatest portion are on their feet.

Densities calculated from the strips are extrapolated for the three regions, and these are then summed for the whole Gir. Areas of the three strata were determined from planimetry of a rather crude map. If and when a better map is available, totals will be recalculated.

(b) *Results and Discussion*

Strip counts were made along some 996 km. of roads: 416 km. in daylight and 580 km. after dark. Considering separately each species estimate in each region, higher density estimates resulted from night counts than day counts in 2 out of 3 cases. Of the most abundant species, chital and nilgai, chital were better represented at night while nilgai results were divided about evenly between day and night counts. Of the four less abundant species, sambar and pig were about evenly represented while four-horned and chinkara were consistently more visible at night. Table 1 shows estimated densities and totals for each region and for the entire Gir.

The results of this survey agree rather well with Joslin's (pers. comm.) survey made one year earlier. His counting was all at night, and his calculations were based on an estimated strip-width of 75 rather than 100 metres. Joslin covered 1,025 km. of roads, but this involved some duplications. He estimated a total of 7,200 ungulates with 5,400 chital as compared to our 6,242 and 4,404 respectively. Had Joslin applied a strip-width of 100 metres, then his total would be 5,400 with 4,050 chital. While the agreement is close for chitals, this year's total of all species is notably larger. It seems reasonable that, by covering the sanctuary more widely this year, a greater diversity of habitat was encompassed, hence the unevenly distributed, rarer species were probably sampled more representatively. Likewise, inclusion of daylight counts probably improved representativeness of some species.

TABLE 1

ESTIMATED DENSITY OF SIX UNGULATES IN THE GIR FOREST BASED ON ROAD STRIP SAMPLING AND CALCULATED SEPARATELY FOR THREE REGIONS OF THE SANCTUARY. THE TOTAL NUMBERS RECORDED DURING THE CENSUS, COMBINING DAY AND NIGHT COUNTS, ARE SHOWN AT THE BOTTOM

Region and its size	Calculated	Species					
		Chital	Nilgai	Sambar	Four-horned	Chinkara	Boar
Western	Number/km² ...	3.05	0.54	0.35	0.31	0.039	0.038
538 km²	Total	1,642	291	186	166	21	21
	Abundance Ratio ...	100	18	11	10	1	1
Middle	Number/km² ...	4.98	0.83	0.26	0.26	...	0.10
348 km²	Total	1,735	289	90	90	...	36
	Abundance Ratio ...	100	17	5	5	...	2
Eastern	Number/km² ...	3.57	1.47	...	...	0.62	0.15
288 km²	Total	1,027	424	...	...	179	45
	Abundance Ratio ...	100	41	0	0	17	4
Gir Forest	Number/km² ...	3.75	0.85	0.24	0.22	0.17	0.09
1,175 km²	Number/mi²	9.7	2.3	0.6	0.6	0.4	0.2
453.5 mi²	Total	4,404	1,004	276	256	200	102 (total 6,242)
	Abundance Ratio ...	100	23	6	6	5	2
	Numbers Counted ...	389	64	26	15	12	5

Chinkara are probably over-estimated. The species prefers the areas where vegetation is most open, hence where the average distance of visibility exceeds the calculated strip-width.

The low figure for wild boar, when contrasted with past observations and reports, suggests a sharp and recent decline in that species. Residents of the Gir claim that boar was the most numerous ungulate but a few years ago. A high frequency of boar among all ungulate skulls now being recovered throughout the forest evidences their recent abundance. While farmers and others are increasing their efforts to eradicate boar from cultivated fields surrounding the Gir, the skulls being picked up for this study are usually well inside the Gir many miles from fields. It is possible the population has suffered a severe epidemic.

The stratified analysis indicates interspecies distributional difference within the Sanctuary. Sambar are most abundant in the west, chinkara in the east, and four-horned antelope in the middle region. Chital and nilgai, the two most numerous species, are more uniformly distributed than the others. Nilgai are notable for existing equally well in the most dense and in the most open of vegetation.

Information gathered on the extirpated black buck indicates that this species was once locally abundant in the flat open areas of the western and eastern margins of the Forest. The disappearance of black buck some 15-25 years ago may well be related to incursions of agriculture across the boundaries of the Sanctuary.

Sex and Age Composition

In travels about the Gir as well as during the census, sex and age are recorded at each sighting of ungulates as long as it is possible to accurately classify every individual sighted at one place and time. During the first months of field work, such classification was impeded by lack of familiarity with growth rates and phenology in the six species. Assuming the necessary criteria will be in hand soon, not only will subsequent classification be more reliable, but some early data can be reanalyzed.

Table 2 summarizes population structure as measured during the first months of this study, the dry season, using provisional criteria of classification. Among limited numbers of four-horned antelope and chinkara classified, no small-sized individuals were recorded. For all species, it is suspected that females are under-represented here. Since groups within which all animals are not classifiable are not recorded, it follows that as size of group increases so also does the probability of that group's not being included in the sample. It appears that females are more

likely to predominate large groups than small ones. If so, females are being undersampled. As a direct consequence, young, as a per cent of the total population, would likewise be underestimated. An adjustment in calculations to avoid this bias has been devised and is being tested: it simply requires that group size be recorded in every encounter whether or not complete classification is achieved.

TABLE 2

AGE AND SEX RATIOS IN FIVE UNGULATES ESTIMATED FROM OBSERVATION SAMPLING DURING MARCH-JUNE, 1970

Species	Adult		Young
	Male	Female	
Chital	35 (97)	100 (274)	31 (84)
Nilgai	89 (55)	100 (62)	4 (31)
Sambar	33 (11)	100 (33)	55 (18)
Four-horned	100 (11)	100 (11)	.....
Chinkara	100 (11)	100 (11)	.....

" Young " is not necessarily year-class I, since criteria of growth and parturition season are not yet available for these species at the Gir. Numbers in parentheses show sample size.

The tendency to aggregate, i.e. display positive social cohesiveness as opposed to mere chance proximity, is measured by the average number seen moving together as a group. Variation in group size can reflect differences in density or in sex or age makeup of the local population as well as reflecting a general tendency within a species to aggregate. Aggregation can vary with feeding habits, time of day, cover, or the point of the annual reproductive cycle. To factor out what regulates grouping tendency requires many types of information. Assuming this information will eventually be uncovered during these investigations, presentation of quantitative results is deferred.

Of all the ungulates, the two most common, chital and nilgai, are the most gregarious, at least during the period March-June. No notable differences in group size appeared for any species by region or habitat type. Unlike chital and nilgai, mixed-sex groupings of sambar, four-horned antelope, and chinkara consistently involved a single adult pair. This suggests breeding behaviour in these last three, but again further information will be required. Pursuing these measurements through the year will be important to determining the timing of mating. In this regard it is noted that chital were dropping antlers just before the monsoon (June), while sambar were in velvet (antlers growing) at that time. It is anticipated the entire picture of phenology of mating and parturition

will be defined for the ungulates of the Gir, and this in turn can be related to resource phenologies and climatic tolerances.

Vegetation Surveys and Grazing Measurements

This phase has not yet produced reportable results; however, considerable groundwork has been laid on several phases of investigation. Berwick mastered the identification of the woody flora of the Gir, during which exercise a collection and series of drawings was made of more than 70 species. Familiarization with herbaceous flora was aided by collections prepared and checked by Mr. Hodd. With Mr. Hodd, grasses are being grown free of grazing to assemble a series of tissues representing various growth stages; these will be used in identifying food items from rumen contents or feces.

To gain familiarity with vegetation patterns within the Gir, Berwick made an extensive foot survey across the Forest, recording composition and frequency in 78 types. Each of these types can be relocated on the ground as well as on aerial photographs. Sampling information included stem density, diameter of stems, height of trees, and composition of shrub and herbaceous layers. During the walk, a tally was made of droppings of domestic stock within a 5-foot strip except near herdsmen's villages (nesses). This index will show relationships between livestock distribution during the dry season and vegetation types.

Initial analyses of the survey reveal that tree density is somewhat uniform from the west through the middle of the Gir but from there eastward decreases sharply. The same can be said for the Forest's dominant species of tree, teak (*Tectona grandis*). On the other hand, diversity of woody species increases from west to east.

Grazing-free plots of grass, maintained by fencing out animals, were established in two widely separated locales. Both sites are well removed from nesses, hence from excessive livestock pressure. The production of herbaceous forage will be estimated by clipping samples within the exclosures; differences between inside and outside clippings at selected seasons will provide estimates of grazing removals. Distinction of wild *vs.* domestic grazing will be possible by using exclosures with differential accessibility: one excludes all ungulates, as well as most smaller herbivores, while the other excludes livestock only. Species of wildlife will be distinguished by feces and by direct observation from concealed vantage points. There are 10 plots exclosed, each 20×20 feet, along with an equal number of matched control plots.

In his work with livestock grazing, Mr. Hodd constructed a series of similar exclosures, mostly near nesses. Results from the present study

will complement Hodd's in that the most heavily and least heavily used areas by livestock will have been studied. Mr. Hodd suffered considerable loss of data from a variety of disturbances within his exclosures. Based on his experience, we have taken special precautions to prevent these serious misfortunes.

Total Production and Demand for Grass

In order to guide the design of measurements and experiments on grazing capacity at the Gir, a speculative model of grass productivity and usage was constructed. This is but a preliminary exercise; nevertheless it suggests the sorts of results which this work, in conjunction with that of Hodd and Joslin, should produce.

The following calculations are based on best estimates of forage consumption among ungulates — wild and domestic — and early results of Hodd's grass production sampling. Data for the entire forest are simulated as means for estimating the optimal stocking level. Criteria of good range management used here are, unfortunately, those relevant to temperate rather than tropical grasslands.

North American range experts generally agree that grass ranges which are "good" to "excellent" can remain in such condition if no more than 50-60 per cent of annual production is removed by grazing (U.S. Forest Service, 1963; Stoddart & Smith 1955; Jameson 1962). However, ranges in "poor" condition will degrade further or fail to recover if more than 25 per cent of annual production is removed. There is little doubt that range scientists would classify much of the Gir as currently in "poor" condition.

Table 3 lists the estimated numbers of each species of ruminant within the Gir, average live weights, and the calculated live weight biomass of each population. Because this is but a working model and most input data are expressed in English measure, metric equivalents are not shown. Table 4 details the procedure for estimating the amount of grass utilized by each species on a per pound live weight basis. From this is calculated with data from Table 3 the total annual demand for grass.

There are approximately 450 square miles of grazing land within the Gir. Productivity of grass is estimated at 542 pounds (dry weight) per acre (Albertson 1959; Hodd 1969). Domestic animals are given supplements of cottonseed and groundnuts (peanuts) at approximately 1.75 pounds per day. In addition to grass removed by animals or cut by herdsmen for domestic animals within the Gir, some 44×10^5 pounds

of grass are cut and removed from the Forest by fodder cutters each year, according to Gujarat Forestry officials.

TABLE 3

POPULATION AND BIOMASS OF UNGULATES IN THE GIR FOREST

Species	Numbers[1]		Average live weight[2]		Species—Average Biomass Lbs. × 10^5
	Adults	Young	Adults	Young	
Zebu Cattle	4,634	2,495	650	200	35.11
Domestic Buffalo	11,806	6,357	900	270	123.42
Nilgai	770	330	500	200	4.50
Sambar	208	52	400	150	0.91
Chital	3,680	920	125	50	5.06
Four-horned	180	45	50	25	.10
Chinkara	160	40	50	25	.09
Subtotals:					
Domestic					158.53
Wild					10.66
Total ...					169.19

1 Population estimates based on unpublished work of P. Joslin plus the present study.

2 Schaller 1967; Taylor 1969; Ledger 1969; Prater 1965.

For those livestock not year-round residents the number shown reflects their number multiplied by the fraction of a year they are present.

TABLE 4

CALCULATIONS OF GRASS CONSUMPTION PER ANNUM BY THE UNGULATES OF THE GIR FOREST WITH CERTAIN INTERMEDIATE DATA SHOWN

Species	Per cent diet Grass[1]	Grass consumed (lbs.) per live weight pound per day[2]	Annual consumption by population Lbs. × 10^5
Cattle	90	.023	294.75
Buffalo	85	.022	991.06
Nilgai	20	.005	8.21
Sambar	40	.010	3.32
Chital	95	.023	42.48
Four-horned	40	.010	0.37
Chinkara	80	.016	0.53
Totals:			
Domestic			1,285.81
Wild			54.91
Total grazing			1,340.72
Fodder cutting			44.00
Total removal/year ... ... (138,471,000 lbs. or 69,235 T)			1,384.72

1 Schaller, 1967; Ledger, 1969.

2 Stoddart and Smith 1955 ; Odend'hal 1969; Albertson 1959; Bilby 1969; Abrams 1969.